

# FINAL REPORT

Title: **Fighting Wildfire with Prescribed Burning in the Southern Great Plains - Social and Regulatory Barriers and Facilitators**

JFSP PROJECT ID: **16-1-02-10**

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<b>PI Name</b>	Urs P. Kreuter
<b>Affiliation</b>	<b>Texas A&amp;M University, College Station, Texas</b>
<b>PI2 Name</b>	Morgan L. Treadwell (Russell)
<b>Affiliation</b>	<b>Texas A&amp;M AgriLife Extension, San Angelo, Texas</b>
<b>PI3 Name</b>	R. Patrick Bixler
<b>Affiliation</b>	<b>University of Texas, Austin, Texas</b>
<b>PI4 Name</b>	Carissa L. Wonkka
<b>Affiliation</b>	<b>USDA Agricultural Research Service, Sydney Montana</b>



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# **Fighting Wildfire with Prescribed Burning in the Southern Great Plains: Social and Regulatory Barriers & Facilitators**

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## **List of Abbreviations/Acronyms**

BB – Barrier-barrier  
 BP – Barrier-process  
 CFI – Comparative fit index  
 ESSM – Department of Ecosystem Science and Management  
 GPFSE – Great Plains Fire Science Exchange  
 GRA – Graduate Research Assistant  
 NNFI – Non-normed fit index  
 NRCS – United States Department of Agricultural Natural Resources Conservation Services  
 PBA – Prescribed burn association  
 TSWCRA – Texas and Southwestern Cattle Raisers Association  
 TWA – Texas Wildlife Association  
 RMSEA – Root mean square error of approximation  
 SGP – Southern Great Plains

## Keywords

Brush control, burn ban, County Commissioners, coupled human and environmental systems, decision making, District Court Judges, fire policy, grasslands, gross negligence, heuristics, land management, landowner attitudes, legal statutes, liability insurance, prescribed burn association, prescribed burning, prescribed fire, private rangelands, risk assessment, rangeland restoration, simple negligence, Southern Great Plains, wildfire mitigation

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*Co-PIs and Collaborators:* Carissa Wonkka provided extensive conceptual, analytical and written input for the District Court Judges, County Commissioners and NRCS survey components; Patrick Bixler and Gerard Kyle provided extensive conceptual, analytical and written input for the Key informant and Landowner survey components; Morgan Treadwell arranged the initial focus group meetings in Texas, provided the names of initial key informants in Texas, was the driver of the highly productive outreach activities and was actively involved in several publications; John Weir arranged the initial focus group meetings in Oklahoma and provided names of the initial key informants in Oklahoma; Diana Doan-Crider was actively involved with the conception of the project and brought the JFSP funding opportunity to our attention; and Dianne Stroman helped produce the initial journal article manuscript. The Great Plains Fire Science Exchange has also actively highlighted the research.

*Graduate Students:* J. Kelly Hoffman (Ph.D.) was the lead graduate research assistant (GRA) for the key informant telephone survey, the on-line survey of TSWCRA and TWA members, and the landowner survey; Lars Coleman (M.S.) was the co-lead GRA for the on-line TSWCRA and TWA member survey and the landowner survey and assisted with the key informant survey; Thomas W. McDaniel (M.S.) was the lead GRA for the County Commissioner survey and assisted with the key informant survey; and Alissa M. Hinojosa (M.S.) was the lead GRA for the District Court Judges survey and the co-lead GRA for the County Commissioner survey.

*Survey participants:* We thank everyone who provided data for the study including: 66 key informants who participated in the telephone interview survey; 39 District Court Judges who completed their questionnaire and 36 Judges who completed the non-response questionnaire; 124 County Commissioners who completed their questionnaire and 55 Commissioners who completed the non-response questionnaire; and 354 Texas and Oklahoma landowners who completed their questionnaire and 108 landowners who completed the non-response questionnaire. Without their participation this study would not have been possible.

## Abstract

Elevated fuel loads and projected hotter and drier climatic conditions will likely lead to more frequent wildfires in the western USA. To ensure prescribed fire is broadly adopted by private landowners to reduce wildfire risks, the attitudes of landowners and county and federal officials who influence the use of this wildfire mitigation tool need to be better understood. The Southern Great Plains (SGP) were selected for this study because they consist predominantly of privately-owned land and have experienced significant woody plant expansion. Specifically, the study focused on Texas and Oklahoma, which are approximately centrally located within SGP. The goal of our research was to conduct an integrative study of legal and regulatory barriers affecting the use of prescribed fire by landowners in the SGP. The five associated objectives were addressed through focus group meetings with diverse stakeholders to gather preliminary information, followed by a series of surveys in Texas and Oklahoma. These included telephone interviews with 66 key informants, and four mail surveys of 192 District Court Judges (response = 20%), 400 County Commissioners (response = 31%), 406 Natural Resources Conservation Service personnel (response rate >50%); and 1,179 private landowners (response = 30%).

Our analysis of key informant input found extensive use of affective heuristics (often linked to emotional tags associated with positive or negative memories) in decision-making regarding prescribed fire use. This suggests that building positive prescribed fire experiences into outreach programs could improve perceptions and use of prescribed fire by diverse stakeholders. Our survey of District Court Judges found that prescribed burn culture plays an important role in how the interpreted fire-related laws. In some states, variability in interpretation of burner negligence has been overcome by Right-to-Burn laws that provide regulatory requirements tied to specific levels of liability. A Right-to-Burn act in Texas and Oklahoma would likely reduce the types of evidence that Judges perceive as constituting negligence, thereby limiting liability and increasing the use of prescribed fire. Most County Commissioners reported being comfortable with prescribed fire but appeared to align with fire prevention attitudes and seemed inclined to pre-emptively enact burn bans and reluctant to approve exemptions. Many depended on input from emergency personnel when making decisions about enacting a burn ban. These findings suggest that inviting Commissioners and emergency personnel to participate in prescribed fires could moderate attitudes about escaped fire risk, leading to fewer burn bans and more exemptions. Our landowner survey conceptualized a process-focused decision-making model with barrier-barrier (BB) and barrier-process (BP) relationships. Statistically significant BB relationships included 1) prescribed-fire-experience and state-of-residence as well as 2) wildfire-experience and land-ownership-for-livestock-or-crop-production. Significant BP relationships included those between the fire-decision-making-process and gender, and property-ownership-for-non-consumptive/recreational use. These findings have implications for three landscape-scale prescribed fire issues: 1) provision of an evolved conceptualization through which prescribed fire implementation decisions can be examined, 2) enhancing prescribed fire outreach to a changing landowner population, and 3) improved content and delivery of prescribed fire education efforts.

While our study provided substantial new information about legal and regulatory factors affecting the use of prescribed fire in the SGP, some aspects of the study were hindered by the departure of a key researcher and the Covid-19 pandemic. ***We recommend future research focusing specifically on the perspectives of District Court Judges and County Commissioners regarding prescribed fire and statutes pertaining to escaped fire across the entire Great Plains.***

## Objectives

The original principle investigator and four and co-principle investigators for this project were: Urs P. Kreuter, Morgan L. Treadwell (Russell), R. Patrick Bixler, Forrest D. Fleischman and Samuel D. Fuhlendorf. However, Fleischman moved to another institution and was unable to participate in the County Extension Agent survey component that he was to lead, and Fuhlendorf, who was not funded by the project, did not engage in it. By contrast, Carissa L. Wonkka, who was included as a consultant in the proposal, engaged in the project to a far greater extent than expected (without her conceptual, statistical and writing contributions, the results of the project would have been far less compelling than they have been) and, accordingly, she is listed as a co-principle investigator on the cover page. Morgan Treadwell, was equally helpful in the production of several highly impactful outreach and published products.

The five original objectives, the associated working hypotheses and the extent to which each objective was accomplished are listed below.

**Objective 1** – Investigate the interactions among parallel as well as hierarchical components of the legal and regulatory framework governing prescribed burning and analyze how these interactions may either constrain or enhance the use of prescribed fire by private landowners.

***Hypothesis 1 – Federal and state laws and federal agency rules that are supportive of prescribed fire use increase state agency support for prescribed burning and influence county commissioner perceptions about the loss of control of prescribed fire, which leads to less frequent burn bans.***

This objective was mostly accomplished through the completion of two mail surveys targeting District Court Judges and County Commissioners. Hierarchical components at the state and federal level could not be readily evaluated. While statutes regarding liability for escaped fire are established at the state level, they and associated regulations, including burn ban enactment, are commonly administered at the county level. For this reason, we focused on the perceptions of Judges and Commissioner regarding the use, benefits and risks of prescribed fire on private land.

**Objective 2** – Evaluate the use of various sources of information about prescribed fire that county extension agents and county commissioners use to advise and make decisions that influence the use of prescribed fire by private landowners.

***Hypothesis 2 – County extension agents and county commissioners who are better informed about the functional role of fire in reducing wildfire risks and in maintaining productive rangelands and forests are more likely to be effective in promoting the use of prescribed fire.***

This objective was mostly accomplished through the completion of two mail surveys targeting County Commissioners and USDA Natural Resources Conservation Services (NRCS) personnel in Texas and Oklahoma. There were two reasons for switching the focus from County extension agents to NRCS personnel: (1) The Co-PI who was to lead the County extension agent survey moved to another institution; and (2) it was discovered that many County extension agents do not focus on land management, specifically prescribed fire, whereas NRCS personnel are generally familiar with this land management tool.

**Objective 3** – Assess how public opinion about wildfire and prescribed fire influence personal membership patterns to formal organizations and networks and the network influence of these associations on the skills, resources and subjective norms of landowners with respect to the application of prescribed fire.

***Hypothesis 3 – Media-driven public perceptions regarding fire are positively correlated with landowners’ formal network orientation towards fire, and that orientation is positively correlated with the skills, resources and subjective norms towards prescribed fire.***

The objective was addressed, in part through an on-line survey targeting all members of the Texas and Southwestern Cattle Raisers Association (TSWCRA) and the Texas Wildlife Association (TWA), and more fully through a multi-contact mail survey of 1200 randomly selected landowners in six counties in Texas and six counties in Oklahoma. It should be noted that the on-line survey resulted in an exceptionally poor response rate (~2% of the TSWCRA and TWA members). In part this was due to these Associations being unwilling to provide membership lists. This necessitated inclusion of a link to the on-line survey in the regular TSWCRA and TWA newsletters, which prevented the use of multi-contact survey methodology that generally generates much better response rates. The mail survey was subsequently conducted to obtain more reliable, albeit geographically more restricted, landowner data. Due to the lack of reliability of the on-line survey data, only the mail survey data are reported.

**Objective 4** – Assess how social and regulatory factors influence landowners’ attitudes about the use of fire, the extent to which they have used prescribed fire on their land in the past, and the extent to which they intend to use it in the future.

***Hypothesis 4 – Social and regulatory factors that positively affect landowners’ attitudes towards fire, either directly or indirectly by their influence on land manages’ subjective norms, are positively correlated with the past and intended future use of prescribed fire.***

This objective was fully addressed through the multi-contact mail survey of 1200 landowners in Texas and Oklahoma.

**Objective 5** – Investigate the potential efficacy of various intervention strategies for increasing the use of prescribed fire by private landowners.

***Hypothesis 5 – Intervention strategies that facilitate the use of prescribed fire, will increase landowners’ willingness to apply prescribed fire.***

This objective was only minimally addressed for two reasons: (1) Other factors affecting the use of prescribed fire were given priority in the landowner surveys so as not to make the survey questionnaires too long, which could have reduced the response rates; and (2) The outbreak of Covid-19 and the associated stay at home orders prevented a follow-up survey to directly determine the effect of prescribed burn association (PBA) membership, access to affordable escaped fire insurance, and remote sensing tools on the use of prescribed fire.

## Background

Elevated fuel loads together with projected hotter and drier climatic conditions will likely lead to more frequent erratic wildfires in the western USA (Luo et al 2013). Paradoxically, perceptions by land managers and policy makers that applying prescribed fire is risky business have contributed to more destructive wildfire in the western USA by encouraging fire suppression and woody plant expansion into grasslands (Briggs et al. 2005). Recognition that changing climate and decades of fuel accumulation are increasing the risks of wildfire has led to calls for fire management reform, including the use of prescribed fire to reduce fuel loads. However, this shift in fire management emphasis is failing to take effect due to entrenched disincentives to work with fire “because of liability and casualty risks and little tolerance for management errors” (North et al. 2015, p. 1280).

Much of the research on wildfires and the debate about fire management reforms have focused on public lands. However, this issue is equally applicable to privately owned rangelands and forests in the western USA, which are frequently the source of or conduit for the transmission of wildfire (Fischer and Charnley 2012). To ensure fire management reform for reducing wildfire risk is broadly adopted on private land in the western states, the attitudes of landowners and county, state and federal officials who influence the use of prescribed fire on private land need to be clearly understood (Toledo et al. 2012; Weir et al. 2019). Most privately owned, fire-adapted rangelands and forests occur in the 22 contiguous states west of the Mississippi River.

Texas and Oklahoma were selected for this study because the Southern Great Plains (SGP) have experienced significant woody plant expansion due to long-term fire suppression, as well as several recent wildfires (Twidwell et al. 2013; Elmore et al. 2010). These states are comprised of 95.8% and 95.4% private land, respectively. The results of this study will contribute to efforts to change state statutes pertaining to escaped fire liability and efforts by the NRCS to expand the use of prescribed fire for restoring ecosystem functionality and mitigating wildfire risks.

Despite the increasing body of literature illuminating the influence of various factors on the use of prescribed fire on private land, there are still significant knowledge gaps regarding social and regulatory barriers to the use of fire to reduce fuel loads. For example, imposition of blanket burn bans by some county commissioners present a regulatory constraint for the use prescribed fire when it may be most effective for reducing invasive woody plants and accumulated fuel loads (Weir et al 2019). Additionally, sensationalized media coverage of wildfire has often lead to misunderstanding by landowners about the ecological function and relative safety of properly applied prescribed fire (Twidwell et al. 2015). The effectiveness of alternative strategies to increase the use of prescribed fire on private land has also not been comprehensively evaluated. An integrative assessment of knowledge gaps and the potential efficacy of alternative wildfire avoidance and mitigation strategies is needed to reduce the risk of loss of life and property damage from wildfire emanating from or traversing across private land.

The goal of our research was to conduct an integrative study of legal and regulatory barriers and opportunities affecting the use of prescribed fire by landowners in the SGP. The research focused three key considerations.

First, legal and regulatory constraints limit the implementation of prescribed fire by affecting landowner liability for escaped fire (Wonkka et al. 2015). Recent studies in Texas and Oklahoma

found that liability concerns are a major reason for landowners to resist the use of prescribed fire (Kreuter et al. 2008, Elmore et al. 2010, Toledo et al. 2013, Weir et al. 2019). It has been found that landowners burn more in states with gross negligence than in states with simple negligence standards (Wonkka et al. 2015). An earlier study also found that legislators seek to balance promotion of prescribed burning for ecological benefits with incentive standards for practicing care in the application of prescribed fire to reduce the frequency and extent of escaped fires (Yoder 2008). In this study we conducted **two mail surveys** to determine the effects of the legal statutes pertaining to escaped fire on **District Court Judges'** and **County Commissions'** perspectives and decisions that may affect the use of prescribed fire by landowners.

The second factor that influences landowner decision-making is their own attitudes towards fire. In many areas, landowners may experience social pressure (subjective norms) that discourage the use of fire (Toledo et al. 2013). Additionally, transfers in land ownership may affect sentiments regarding the use of prescribed fire, as newer landowners often have different values and priorities on their land (Sorice et al. 2014), such as preferring dense brush that provides privacy. Additionally, landowners may be persuaded to apply prescribed fire more readily through the use of land improvement initiatives, such as Environmental Quality Incentive Program that is administered by the NRCS. To address these issues, we conducted **one mail survey of landowners** to determine their attitudes and values regarding woody plants and the use of prescribed fire, and we also conducted **one mail survey of NRCS personnel** who are key providers of information about land management.

The third factor that influences landowner decision-making is knowledge of how to use prescribed fire safely. Of particular importance in this regard are PBAs, which provide members with fire safety training, equipment and experienced labor to apply prescribed fire safely on their land (Taylor 2005, Toledo et al. 2014). Since their inception in Texas in 1997, PBAs have proliferated across many Great Plains states to the north (Twidwell et al. 2013). We used our landowner survey to examine the impact of participation in PBAs on prescribed fire use.

The primary benefit of the research is that it addresses current knowledge gaps about barriers to the use of prescribed fire by landowners in a region where rapid woody plant expansion together with hotter and drier climatic conditions are leading to increased risks of catastrophic wildfires. A more comprehensive understanding about social and regulatory barriers for the use of prescribed fire and the efficacy of alternative wildfire avoidance strategies will be relevant for the development of policies aimed at the expanded application of prescribed fire on private land throughout the western USA where fuel loads have increased due to woody plant expansion and/or long-term fire suppression. Additionally, the benefit of the outreach component of the project is that it will provide information about the efficacy of alternative strategies for overcoming some of these barriers.

## Materials and Methods

The research conducted under this project consisted of three focus group meetings, personal interviews with 66 key informants, and four mail surveys. The methodology used for each is described chronologically below. Approval was obtained for the research under IRB2017-0364M; IRB2017-0735M and IRB2018-0015.

### Study Area

The study was conducted in Southern Great Plains (SGP) ecoregion of the United States. The SGP encompass nearly 73 million hectares of land encompassing eastern Colorado and New Mexico, nearly all of Kansas and Oklahoma, and northern and central Texas, extending as far south as the Gulf of Mexico (EPA 2016). The dominant land cover type of the SGP has historically been semi-arid grassland, with shortgrass prairies in the west transitioning along the precipitation gradient to mixed prairies and tallgrass prairies in the east. These ecosystems are typically dominated by various species in the *Poacea* family. However, with prolonged fire suppression, large areas have become dominated by woody plants, particularly *Juniperus* spp. Due to land conversion and woody plant encroachment, less than 30% of the original grasslands remain, with tallgrass prairies comprising only 4% of their former range, while shortgrass (52%) and mixed grass (29%) prairies have fared somewhat better but exist mainly as imperilled scattered patches (Samson and Kopf 1994, Samson et al. 2004).

The investigation reported here focused on the central portion of the SGP found in Texas and Oklahoma, and incorporated 208 counties in Texas and 70 counties in Oklahoma (Assal et al. 2015). Both states consist of >95% privately owned land and have experienced significant woody plant expansion and catastrophic wildfires in recent years (Twidwell et al. 2013; Elmore et al. 2010; Donovan et al., 2020).

Texas and Oklahoma apply simple negligence liability standards to escaped prescribed fire cases. This means a plaintiff must show negligence – a breach of the duty to use ordinary care – in order for the defendant to be held liable for any damages resulting from an escaped fire. Landowners wishing to burn their land are required to file a burn plan, have a plan for mitigating smoke hazards, create proper firebreaks, and have sufficient manpower and equipment to conduct the burn (6 Tex. Nat. Res. Code Ann. §153; 2 OK Stat § 2-16-28.2, (2016)). One difference between the two states is the parties that must be notified when burn is going to be conducted; while Oklahoma requires notification to neighbors and the local fire department, Texas requires notification to the Texas Forest Service (30 Tex. Admin. Code §111.219 (1996)).

### Focus Group Meetings

Three focus group meetings were conducted in College Station, San Angelo in Texas and Stillwater in Oklahoma in December 2016 and January 2017. The purpose of these focus group meetings was to get initial input from a broad spectrum of stakeholders regarding the key issues pertaining to the social and regulatory aspects about the use of prescribed fire in the SGP. Notes from these focus group meetings were used to develop the subsequent components of the research project.

## **Key Informant Interviews**

This component consisted of 66 key informant interviews conducted between May and August 2017. The initial six key informants were identified by one of the project's Co-PIs in Texas and a collaborator in Oklahoma who were very familiar with each state's prescribed fire culture. A purposive snowball sampling method was utilized thereafter, whereby the initial six interviewees were each asked to recommend two additional potential interviewees, who in turn were also asked to recommend potential additional interviewees. Ideally, these recommendations included both burn practitioners and non-practitioners. Representatives were sought from federal agencies, state agencies, non-profit entities, burn associations, and private landowners or ranch managers in both states. The interview process was terminated when data saturation was achieved and new interviewees began to consistently provide similar responses as the preceding interviewees.

The recorded interviews were conducted by telephone and used a predetermined series of questions that focused on three main areas of interest: 1) the interviewee's past history with prescribed fire and wildfire, 2) the interviewee's attitudes and perceptions regarding the benefits and risks of using prescribed fire, and 3) the interviewee's familiarity with their respective state's statutes on prescribed fire liability. The recorded interview responses were transcribed by a professional transcription service and uploaded to NVivo 12 Plus. Three independent coders then conducted an emergent themes analysis. Inter-coder themes with large content overlap were combined to create a master theme list that included three major themes: 1) cognition concerning and perception of prescribed fire; 2) communication about prescribed fire; and 3) utilization of prescribed fire. Coders then read each interview three additional times, only coding for a third of the master list on any given reading to ensure coding accuracy. Percent agreement of coding between each pair of coders averaged 96%, with >90% representing high agreement; and the average Cohen's kappa was 0.73, with a range of 0.60-0.80 considered substantial agreement. Subsequently, a second thematic analysis that focused on decision-making processes revealed a previously undetected additional latent theme; the affect heuristic processes in decisions about the implementation of prescribed fire. Finally, individual excerpts comprising the decision-making theme were coded to one of three decision-making process categories with respect to the implementation of prescribed fire: analytical, heuristic, and dual-process.

## **District Court Judges Mail Survey**

The study population for this component of the research included all district Judges in 208 Texas counties and 70 Oklahoma counties within the SGP. The study was based on a survey of a sample of 200 randomly selected Judges, including 100 from Texas and 100 from Oklahoma, representing 27% of all district Judges in the study population.

The mail survey questionnaire consisted of approximately 20 multi-part questions covering three key areas of inquiry: 1) Judges' knowledge of prescribed fire and prescribed fire statutes; 2) their perspectives on differences between gross and simple negligence standards; and 3) valuation theories relating to possible awards for damages resulting from escaped fires. The mail survey was conducted from February through June 2018 using a four-phase mailing protocol (Dillman et al. 2014), which included a pre-survey notification; the survey questionnaire with a cover letter; a reminder card; and a replacement survey questionnaire with another letter. A one-page follow-up questionnaire was also sent to all non-responding Judges in November 2018 to determine the reasons they decided not to participate in the study and to ascertain if there was a

non-response bias (Armstrong and Overton, 1977). This questionnaire included six questions from the initial survey questionnaire asking Judges the time spent in the legal profession and time on the bench, whether they had heard cases involving damages from a prescribed fire, whether they were familiar with the state statute regarding agricultural burning, and their understanding of valuation theory for fire-damaged trees.

The data were analyzed to test four hypotheses: [H1] Judges' familiarity with and perception of prescribed fire will be an important driver of their decision-making regarding cases for damages from escaped prescribed fires; [H2] Judges in both states would be familiar with prescribed fire because a large portion of both states have active prescribed burning associations and both states have active state-wide alliances of prescribed burners which seek to increase the acceptability of the practice to the public; [H3] Judges would alter jury instructions and have a higher bar for proving burner negligence when gross negligence was applied as the liability standard than when simple negligence was applied as the standard; and [H4] Judges would prefer expert evidence to come from practitioners rather than academics.

Due to the low response rate, the number of data points were insufficient to conduct robust quantitative analyses for many questions. In these cases, we calculated means and standard deviations of responses and presented the data in a manner appropriate to making qualitative comparisons across states. These qualitative data provide some insight into Judges' familiarity and perception of prescribed fire and differences between Judges in the two states, but do not allow us to directly assess hypotheses 1 or 2. To test hypothesis 3, we developed two questions that asked Judges to choose from a list all applicable facts that would alone constitute evidence from which a jury could reasonably conclude that a defendant was negligent under simple versus gross negligence standards. We modelled the difference in the number of variables selected as evidence of simple negligence versus gross negligence using a generalized linear mixed model fit by maximum likelihood with Poisson distribution for the count data. To assess hypothesis 4, Judges were asked to rank each of five given categories of expert witnesses on a scale of 1-5 (least preferred to most preferred, respectively). Again, the small sample size did not allow for a rigorous statistical assessment of hypothesis 4, but we present the data to provide some information on preferred expert witnesses in the two states.

### **County Commissioners Mail Survey**

The study population for this component of the research included all County Commissioners in 202 Texas counties and 69 Oklahoma counties falling within the SGP ecoregion. Based on the larger number of Commissioners in Texas (1016) than Oklahoma (231), 300 Commissioners from Texas and 100 from Oklahoma were selected for the study. This sample was derived by randomly selecting one Commissioner per Texas county and two Commissioners per Oklahoma county, and then randomly selecting additional Commissioners from the total pool of Commissioners in the included counties in each state until the target numbers were reached.

The study was conducted using a mail survey questionnaire that was designed using input from focus groups meetings. The survey was conducted during May-July 2018 using a four-phase mailing protocol (Dillman 2014), including a pre-survey notification; questionnaire with a cover letter; a reminder card; and a replacement questionnaire. A non-response survey was conducted by sending a one-page questionnaire to all non-responding Commissioners, which included seven questions; why they had not participated in the study and six key questions from the initial

questionnaire to allow pair-wise comparisons of responses from survey participants and non-participants.

Data were analyzed to address five objectives: [1] Determine factors that influence Commissioners' decisions to enact burn bans; [2] Identify criteria used to make those decisions; [3] Determine whether comfort level with prescribed fire plays a role; [4] Determine if a shift from simple to gross negligence would lead to more pressure to enact burn bans; and [5] Determine if a shift to gross negligence would impact their decision to enact burn bans.

Data from the returned questionnaires were coded to numerical values and digitized to an Excel spreadsheet. Descriptive statistics were derived for all response variables, and frequency distributions were calculated for the results of categorical variables. Multivariate imputation by chained equations was used to obtain values for missing data, which were assumed to be missing at random. Participants were dropped if they left >40% of the questionnaire blank, and variables were removed if >10% of the respondents provided a null response. Variables that prevented convergence of multiple imputation models because of collinearity were also removed. The five objectives were explored using logistic regression for binary dependent variables, ordered logistic regression via proportional odds models for ordered categorical dependent variables, and tests for simultaneous pairwise marginal independence for multi-response categorical variables. We used a nonparametric bootstrap procedure to approximate the sampling distribution of  $X^2$ .

### **Natural Resources Conservation Service Mail Survey**

The study population for this component consisted of all NRCS personnel with verifiable addresses in Texas and Oklahoma and with the title of District Conservationist, Natural Resource Manager, Natural Resources Specialist, Rangeland Management Specialist, and Soil Conservationist. Survey questionnaires were sent to all 406 of these NRCS personnel (293 in Texas and 113 in Oklahoma). The response rates were 53% and 54% for Texas and Oklahoma respectively. Given this high response rate (i.e., >50%), a follow up non-response bias survey was not conducted. The data have been coded and entered into a spreadsheet and are scheduled for analysis in November 2021.

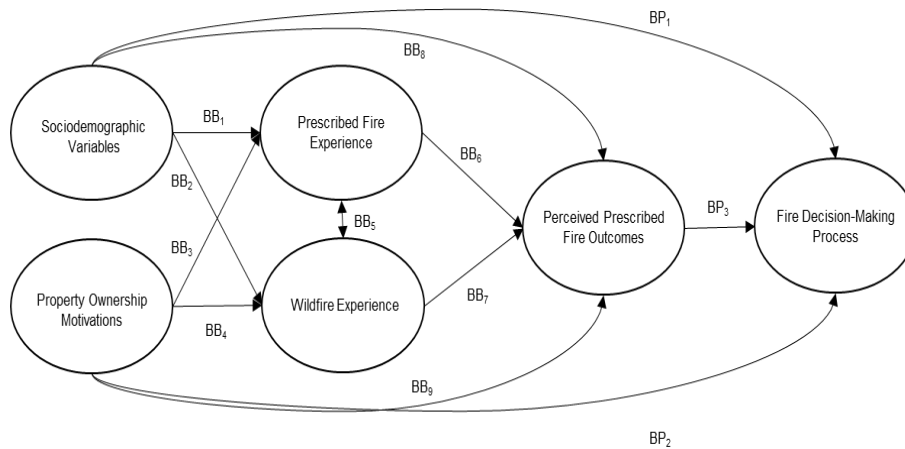
### **Landowner Mail Survey**

This component of the research consisted of a survey of landowners in six rural counties in Texas and six in Oklahoma. Half of the counties in each state were selected based on having an active PBA. Open-access county tax appraisal roles were utilized to randomly select participating landowners with properties of at least 20 ha (~50 ac). Fifty landowners were randomly selected from each of two property size strata (20 to 64 ha and > 64 ha) in each of the 12 counties for a total sample size of 1,200 landowners.

The survey consisted of five mailings (Dillman 2014): a pre-survey letter, the questionnaire with a cover letter and post-paid return envelope, a reminder postcard, replacement questionnaire to non-respondents, and final reminder postcard to all remaining non-respondents. Additionally, a one-page questionnaire was sent to all non-respondents after the end of the survey period to determine why they did not participate and to obtain data for key survey questions to conduct a nonresponse bias analysis. Our dependent variable, prescribed fire decision making process, was

measured with 11 items using a semantic differential response format. The items were used to create an index of respondents' decision-making processes relative to prescribed fire use.

Missing decision-making process data (24% missing at random) were estimated using multiple imputation with chained equations in STATA SE 15.1, 2019. All present values for all survey questions were used to estimate all missing values, thus preserving the uncertainty of the missing data while also providing a more accurate estimation than other missing data estimation techniques. Twenty imputations were created utilizing the seed number '2031,' and the imputed values were then averaged across all imputed sets to create a single, complete dataset. The hypothesized model (Figure 1) was tested using covariance structure analysis. Due to the mixture of categorical, ordinal, and continuous measures, the analyses were based on biserial and asymptotic covariance matrices using the weighted least squares estimator. Multiple fit indices were utilized to assess the proposed model's adequacy. These included the root mean square error of approximation (RMSEA)  $\leq .08$ , the comparative fit index (CFI) and non-normed fit index (NNFI)  $\geq .95$ . Collectively, these fit indices help determine the plausibility of the hypothesized relationships being tested in the model.



**Figure 1.** Process model of the relationships among inter-barrier and barrier-process relationships to the prescribed fire decision-making process. (Note: BB<sub>1</sub>-BB<sub>9</sub> refer to inter-barrier relationships and BP<sub>1</sub> – BP<sub>3</sub> refer to barrier-process relationships).

## Results and Discussion

As in the previous section, results and discussions are presented for each of the five primary research components (personal interviews; four mail surveys) as well as the outreach and science delivery activities.

### Key Informant Interviews

Our analyses revealed the extensive use of heuristics in decision-making regarding the implementation of prescribed fire. Heuristic decision-making processes were defined as decisions in which interviewees used emotive language to describe fire-related decisions, whereas analytic processes were defined as instances in which interviewees used quantitative process to make fire-related decisions. Thirty-three interviewees reported 73 discrete instances of decision-making about fire implementation or fire-related choices. Of these 73 instances, interviewees reported using heuristic processes in 47% while analytic processes were used in 23% of decisions. A dual-process approach, in which both emotive language and quantitative processes were mentioned in making fire-related decisions, was used in 27% of decisions; on multiple occasions instances coded as dual process were in reference to liability issues, which are both emotive and rational. In less than 3% of decisions, the processes used to decide not to implement prescribed fire were indeterminate.

While heuristic processes were documented twice as frequently as analytic processes, the latter resulted in a three times greater likelihood of prescribed fire use; when analytical processes dominated decision-making, the likelihood of prescribed fire use was 100%. This suggests that, provided there are sufficient high-quality data and ample time to decide, analytic processes are superior to heuristic processes for ensuring ecologically desirable outcomes of periodic fire in the SGP.

The preceding results confirm our *first hypothesis* that affect-heuristic processes are used more often than their analytical counterparts in prescribed fire-related decision-making. They also confirm our *second hypotheses* that analytic decision-making processes lead to a greater likelihood of prescribed fire implementation than heuristic processes.

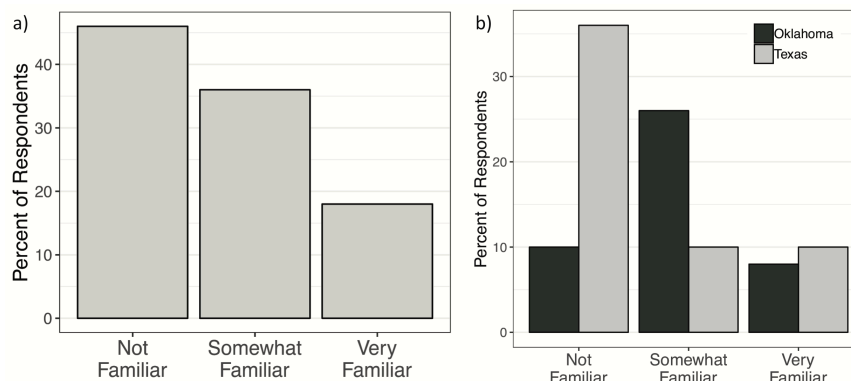
Affective heuristics often rely on emotional tags associated with memories of earlier reports or experiences. Prescribed fire implementation is often spuriously intermingled by the general public with wildfire (Twidwell et al. 2015) and can be erroneously labelled as an unsafe practice due to these emotional forces. Therefore, heuristic processes can generate negative cues associated with statistically low probability risks of prescribed fire, which subsequently leads to low tolerance for fire implementation. When heuristics drive decisions that are not in agreement with the facts of prescribed fire, this disagreement often stems from systemic biases in the way heuristics function (Tversky & Kahneman 1974; 1981).

By identifying and acknowledging the use of heuristics and negative biases in prescribed fire decision-making, land management professionals can consider the implications for both how fire policies are formulated and the way the practice is discussed and taught. A more accurate depiction of how individuals decide to implement prescribed fire has significant implications in a number of contexts, including: 1) Long-term county burn bans; 2) prescribed fire insurance policies; and 3) outreach and education.

## District Court Judges Mail Survey

The initial mailing to 200 Judges led to an effective survey sample of 192 Judges, from which we received 39 completed questionnaires resulting in a response rate of 20.3%. Of the 39 usable questionnaires, 56.5% were from Texas and 43.5% were from Oklahoma. We also received 36 completed follow-up non-response questionnaires, representing a 24% response rate of the 151 initial non-respondents. We found no statistical evidence for nonresponse bias and, therefore, despite the relatively low response rate, our findings can be extrapolated more broadly to the target population of district Judges in the SGP counties in Texas and Oklahoma.

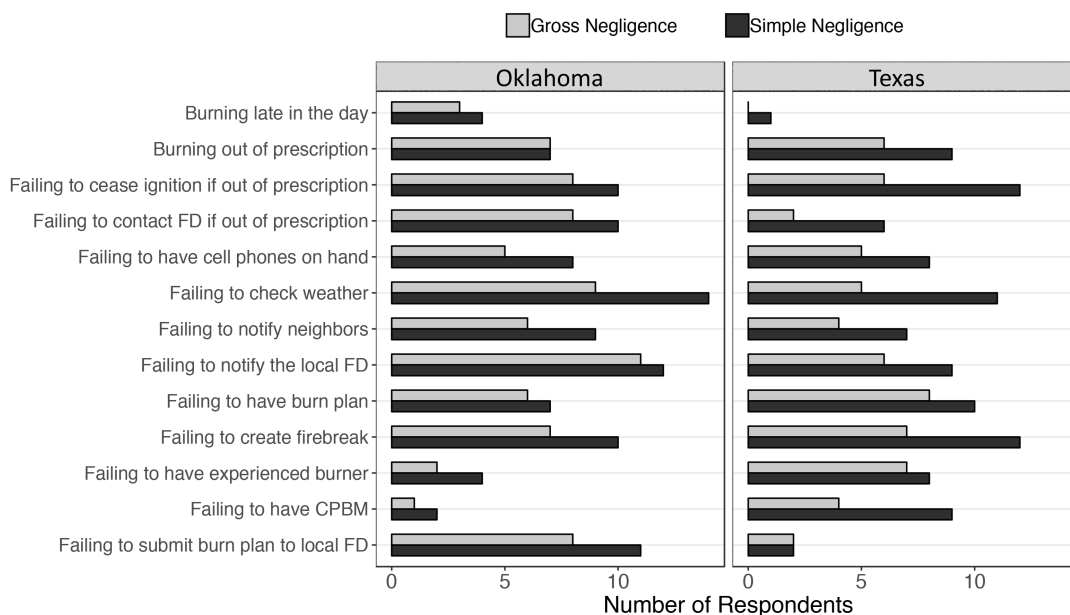
When asked about their familiarity with prescribed fire, 17.9% reported being very familiar, 35.9% somewhat familiar and 46.2% not at all familiar with this land management tool (Figure 2a); at least some level of familiarity with prescribed fire was significantly greater in Oklahoma than in Texas ( $X^2 = 7.748$ ;  $p = 0.005$ ; Figure 2b). Despite nearly half of the respondents indicating unfamiliarity with prescribed fire, 74.3% identified wildfire control through fuel load reduction (more so in Texas), herbaceous plant regeneration, and control of invasive species (specifically *Juniperus virginiana* in Oklahoma) as benefits of using prescribed fire.



**Figure 2.** Results of (a) the Judges' self-reported familiarity with prescribed fire overall, and (b) grouped by state (N Texas = 22, N Oklahoma = 17).

When the Judges were asked what instructions they would give a jury in an escaped fire case, 7 did not provide a response, 2 responded that they did not know, 6 responded they had never heard such a case and were unwilling to express an opinion, 18 stated they would use the language in the law about the legal liability statute for their state; and 6 from Oklahoma said they would use Oklahoma Uniform Jury Instructions. When asked how their instructions to the jury would change if the liability standard in their state were amended to require a finding of gross negligence, 20 (51.3%) reported that they would provide the jury with the legal definition of the new liability standard (i.e. gross negligence instead of simple negligence).

Factors listed as choice options for Judges to indicate what would constitute evidence that a burner failed to exercise adequate care in the case of simple negligence or gross negligence, as well as the frequency of selection of these factors by the respondents are presented in Figure 3. On average, respondents indicated that about 1.5 times more of the undisputed facts would constitute evidence of a failure to exercise ordinary care ( $6.95 \pm 1.12$ ) than would constitute evidence that the defendant failed to exercise even slight diligence and was grossly negligent in conducting the fire ( $4.60 \pm 1.11$ ) ( $z = -3.67$ ,  $p < 0.001$ ).



**Figure 3.** District Judges’ selection of factors that constitute evidence from which a jury could reasonably conclude that a burner failed to exercise adequate care in the case of (a) simple negligence or (b) gross negligence in the Southern Great Plains, USA.

Overall, respondents ranked certified burner trainers and professional wildland firefighters highest for expert witnesses they would prefer to provide evidence in a prescribed fire case. The only major interstate difference in rankings occurred with respect to the rural fire chiefs; in Oklahoma they ranked highly as expert witnesses in the case of an escaped fire trial, but in Texas they ranked lowest among the five categories of potential expert witnesses.

Liability concerns have been recognized as important barriers to prescribed fire use across the USA (Haines and Cleaves, 1999; Haines et al. 2001; Brenner and Wade, 2003; Yoder et al., 2004; Kreuter et al. 2008, Bendel et al. 2020; Miller et al. 2020) and in other countries (e.g., Eburn and Cary 2018). Our aim through this study was to provide clarity on how the laws and regulations pertaining to prescribed fire will be applied by Judges. This clarity can reduce uncertainty regarding potential liability, eliminating one potential barrier to prescribed burning on private lands. Our preliminary study provides insight into potential policy shifts for lowering the likelihood of Judges deciding against burners in escaped prescribed fire cases. In addition, our methodology offers an example for obtaining information on how Judges might adjudicate a prescribed fire case in other regions of the USA and in other countries.

Given that fear of liability is a commonly cited deterrent to the use of prescribed fire by private landowners, limiting the types of evidence that support a finding of liability could help increase the number of private landowners willing to conduct prescribed burns. Gross negligence liability standards have been shown to increase the amount of private land prescribed burning over states with simple negligence liability standards, even when there are stricter regulatory requirements to offset the less stringent liability standard (Wonkka et al., 2015). Therefore, the stricter regulatory environment attendant to a lower liability standard, which is typical of Right-to-Burn Acts, is not expected to be a deterrent to burning.

A stronger fire culture might prove beneficial in changing social constructs and breaking down the barriers to prescribed fire, and could be important in determining how Judges will interpret burner negligence and evidence of negligence in an escaped prescribed fire case. In Oklahoma, where the regulatory requirements are less intensive than in Texas, Judges were more inclined to choose fewer of the options as evidence of either simple or gross negligence. The Texas respondents, especially those familiar with the simple negligence standard, appeared to be more likely to choose more criteria for simple negligence but then drop those criteria in reference to gross negligence. This suggests that in effect, despite both states having simple negligence standards, Oklahoma Judges apply a less stringent standard, seeing far fewer errors as evidence that would alone constitute simple negligence, while Texas Judges see more mistakes as constituting evidence of simple negligence.

In addition to reducing the potential for liability, a well-developed fire culture that is enhanced by a more fire positive judiciary can promote the establishment of PBAs (Twidwell et al. 2013). These associations are networks of landowners that are useful for natural resource agencies because they can extend the reach of agencies by disseminating knowledge through personal interactions among members and by providing a vehicle through which members can share equipment and qualified personnel (Toledo et al. 2014). Moreover, by facilitating interactions between prescribed burn managers and county Judges, PBAs could help increase Judges' familiarity with the importance and relative safety of properly conducted prescribed burning. This could reduce the likelihood of findings against burners even in a law suit brought under a simple negligence liability standard.

### **County Commissions Mail Survey**

Of the 400 selected County Commissions, 124 (31%) returned questionnaires. Of the 276 Commissioners who did not participate, 55 (20%) completed the non-response questionnaire. The non-response bias analysis indicated that respondents were more likely to be familiar with prescribed fire, to have spent more time on fire related issues, and to be comfortable with prescribed fire (all at  $p < 0.001$ ), and also to have participated in a prescribed fire ( $p = 0.025$ ). These results indicated that the respondents represent a subset of Commissioners with more direct exposure to and experience with prescribed fire than non-respondents.

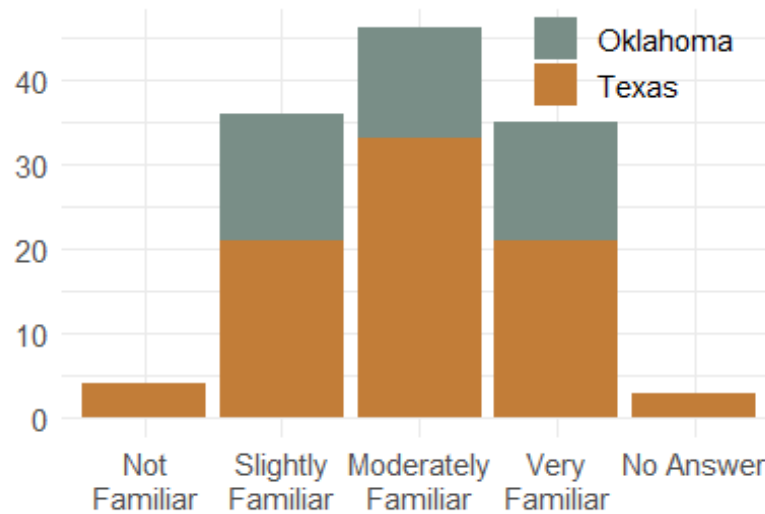
About half of the respondents (52%) had been invited to participate or had participated in a prescribed fire; 47% of them did so as a volunteer, and 70% of them did so with private landowners rather than a government agency or a PBA member. The most common prescribed fire information sources used by respondents were the local fire department, fire chief, or emergency services (67%) followed by State Forest Services (40%). Of the respondents, 97% reported some familiarity with prescribed fire, and most reported being comfortable with prescribed fire (84% selected a positive score for "*level of comfort*").

Only 7 of the responding Commissioners (5.6%) indicated they had never enacted a burn ban. Respondents who were not familiar and somewhat familiar with prescribed fire had all enacted burn bans. Thirty-six Commissioners (29%) stated they were unaware of any exceptions for burning during a burn ban despite the fact that exceptions are allowed in both states. Response patterns for both burn ban enactment and awareness of exemptions were similar in Texas and Oklahoma. Increasing comfort with fire by one unit increased the likelihood that a Commissioner would be aware of burn ban exemptions by a factor of 1.86.

Holding all other variables constant, the likelihood of selecting a higher level of comfort with fire increased by 1.99 times with each 1 step increase in familiarity with fire and the likelihood of selecting a higher comfort level increased by 2.36 times if a Commissioner was a rural landowner (Table 1). Most Commissioners (and all Oklahoma respondents) reported being at least slightly familiar with prescribed fire (Figure 4).

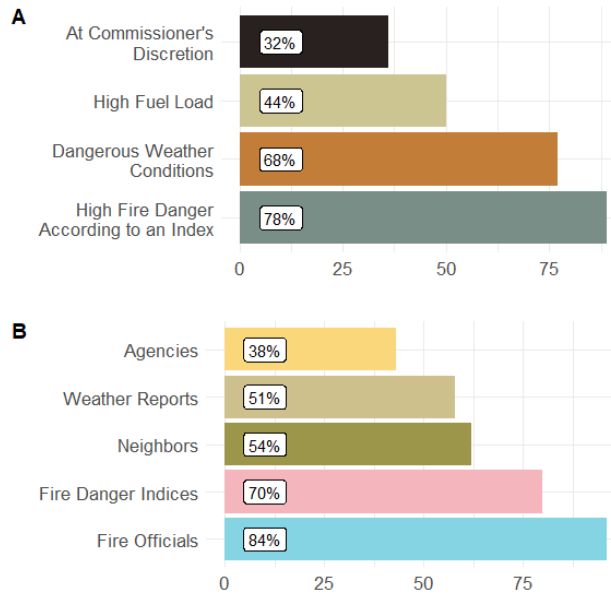
**Table 1.** Regression results for Commissioners' comfort with prescribed fire.

Term	log odds	std.error	statistic	df	p.value
Familiarity with fire	0.57	0.24	2.31	107.62	<b>0.02</b>
Participated in RX Fire	0.03	0.40	0.06	93.67	0.95
Rural Land Owner	0.86	0.43	2.01	94.94	<b>0.05</b>
Years as Commissioner	-0.03	0.03	-0.93	108.11	0.35
Female	0.48	0.67	0.72	97.97	0.47



**Figure 4.** The proportion of Commissioners who reported being familiar with prescribed fire. Texas respondents are shown in brown and Oklahoma in gray

Commissioners most commonly selected high fire danger index as a criteria that must be met to enact a burn ban, followed by dangerous weather conditions, and high fuel load; 32% of Commissioners indicated there were no criteria that needed to be met and Commissioners could enact burn bans at their discretion (Figure 5A). There was an association at  $p < 0.10$  between familiarity with prescribed fire and the criteria identified as necessary to enact a burn ban. The contingency table revealed a relationship between being very familiar with prescribed fire and selecting high fire danger index as criteria for implementing a burn ban ( $p = 0.03$ ). The most commonly selected information source Commissioners used in determining whether to enact a burn ban were fire officials and fire danger indices (Figure 5B). There was an association at  $p < 0.10$  between information sources selected and familiarity with fire. Bonferroni-adjusted  $\chi^2$  values for the contingency table combinations show that commissioners who were very familiar with fire, more frequently selected fire officials as a source of information commissioners who selected one of the other 3 categories of familiarity ( $p = 0.04$ ).



**Figure 5.** Number of respondents that (A) selected a particular category of criteria that must be met in order to enact a burn ban, and (B) selected a particular category of information source they used in deciding to enact a burn ban. The numbers in the white labels add up to more than 100% because respondents could select more than one category.

Only 25% of the Commissioners thought that a shift in the liability standard that was applied to escaped prescribed fire cases in their state from simple negligence to gross negligence (a less stringent standard) would change the amount of pressure they would receive from the public to enact burn bans. Of those, about half thought it would increase the pressure and half thought it would decrease the pressure. Moreover, most Commissioners responded that such a shift in the liability standard for escaped prescribed fire would not alter the frequency with which they would enact burn bans. Of the 30% who stated that the frequency of burn ban enactment would likely change (Table 2), about half thought the frequency would increase and half thought it would decrease, with more Oklahoma respondents stating they would enact fewer burn bans and more Texas respondents stating they would enact more burn bans. Commissioners who indicated that a change in the liability standard would affect public pressure were 10.9 times more likely to say that they would change the frequency with which they enacted burn bans.

**Table 2.** Regression results for whether a Commissioner said that a shift in liability for escaped prescribed fire cases from simple to gross negligence would change the frequency of burn ban enactment.

Term	log odds	std.error	statistic	df	p.value
(Intercept)	-3.71	1.85	-2.00	66.19	0.05
Comfort with RX fire	0.18	0.34	0.54	80.83	0.59
Thinking pressure from public would change	2.39	0.55	4.38	92.08	<0.01
Somewhat Familiar	-0.21	1.16	-0.18	92.34	0.85
Moderately Familiar	-0.09	0.84	-0.11	109.22	0.91
Very Familiar	0.11	0.54	0.21	95.44	0.83
Participated in RX Fire	0.06	0.65	0.09	22.28	0.93
Years as Commissioner	-0.03	0.04	-0.95	99.95	0.34
Rural Land Owner	0.37	0.74	0.50	21.99	0.62
Female	1.42	1.26	1.13	62.52	0.26

To maximize the benefits of applying prescribed fire to increase forage productivity and reduce wildfire risks, it is important to burn rangelands when invasive woody plants and accumulated fuel loads are most effectively reduced. The mortality of invasive woody plants in the SGP, especially *Juniper* species, is generally maximized when fire intensity is high (Fuhlendorf et al. 2008; Twidwell et al. 2016). However, the hot and dry conditions under which such fire intensity occurs are commonly the same conditions that lead to the implementation of burn bans due to heightened concerns over escaped fire (Weir et al. 2019). In Texas and Oklahoma, County Commissioners are responsible for implementing and repealing bans on outdoor burning. As elected officials, Commissioners may feel pressure to implement and enforce burn bans due to widespread but often misdirected public anxiety regarding prescribed fire safety. While burn bans may be prudent for short-term reductions in escaped fires, they can also inhibit the use of prescribed fire for mitigating long-term wildfire risks. To better characterize this quandary, factors affecting the decision-making of Commissioners regarding burn bans needs to be understood but such information has been lacking.

Commissioners most commonly selected periods of high fire danger, either according to an index or weather variables, to enact a burn ban but about one third felt they could enact burn bans even when there is no indication of high fire danger. While relying on a fire danger index is more predictable than making decisions without specific criteria, burn bans during low-fuel moisture conditions inhibit the ability of managers to burn when conditions are most conducive for high-intensity burns required to suppress invasive brush species and, therefore, most effectively reduce fuel loads and wildfire risk. While we found no direct correlation indicating that the local fire department, fire chief, or emergency management coordinator (from which Commissioners most commonly obtained prescribed fire information) influence Commissioners' decisions about burn bans, they may represent an important target group for outreach and education efforts about the benefits and relative safety of prescribed fire that is applied during periods when they most effectively reduce invasive woody plants. Inviting more Commissioners and emergency personnel to participate in prescribed fires, especially those conducted during burn bans, could help overcome factors that promote unduly long burn bans and may lead to greater support for burn ban exemptions during periods when prescribed fire most effectively mitigates wildfire risk.

Based on the findings of Wonkka et al. (2015), we expected Commissioners to indicate that they would enact fewer burn bans following a shift in escaped fire statutes from simple to gross negligence. However, most respondents reported that such a shift would likely not affect the frequency of burn bans, suggesting that many of them either do not embrace the potential to increase prescribed fire use by changing liability standards or that their fire prevention view of burn ban enactment may override such considerations. Commissioners who thought such a shift would change public pressure were nearly 11 times more likely to say they would change the burn bans frequency, with more Oklahoma respondents indicating they would enact fewer burn bans and more Texas respondents indicating more burn bans. The implications of fewer burn bans is that the length of burn windows could increase leading to a more proactive fire culture, whereas the potential increase in burn ban enactment in Texas could further inhibit the application of prescribed fire, which would lead to unmanaged brush encroachment and more accumulated fuel loads for wildfires. Greater interaction with Commissioners by those seeking to use prescribed fire for brush management could increase the willingness of Commissioners to limit burn ban enactment or grant exemptions more readily.

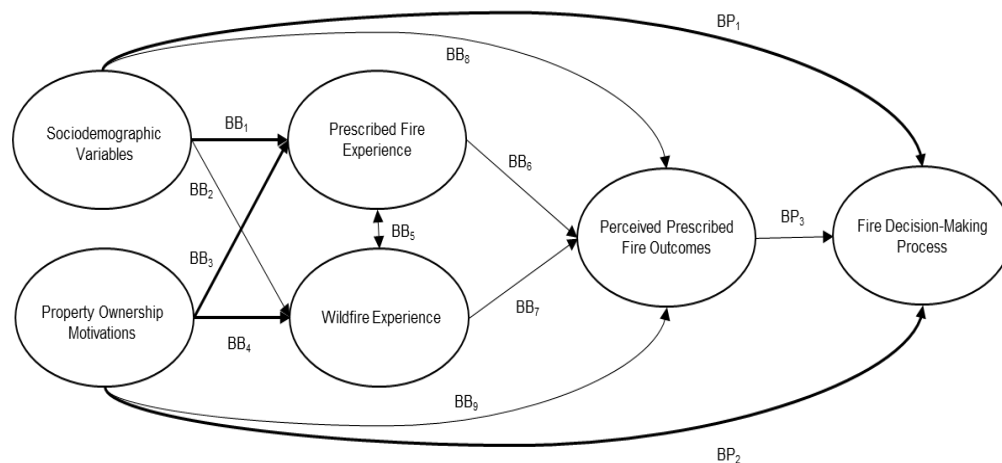
## Natural Resources Conservation Service Mail Survey

The data for this component of the research are currently being analyzed and the associated manuscript is being prepared. It is anticipated that the manuscript will be submitted by the end of 2021. Once accepted, the manuscript will be forwarded as an addendum to this report.

## Landowner Mail Survey

Of the 1,200 contact addresses selected for the study, 21 mailings were undeliverable resulting in a sample size to 1,179, of which 354 (30%) usable responses were received. The non-response bias survey resulted in a response rate of 13% from the 825 initial non-respondents. Statistically significant response differences between the survey respondents and non-respondents were found for four variables, including longevity of land ownership, opinion about prescribed fire, and opinions about fire's efficacy as a fuel load reduction and woody plant control tool. Due to these statistically significant differences, the results of the study are not extrapolated to the overall landowner population in the 12 study counties.

The results of the path analysis used to test the hypothesized model are presented in Figure 5. RMSEA, CFI, and NNFI goodness of fit indices used to ensure adequate fit of the model were all determined to be adequate and statistically significant associations are reported in Table 3. The nature of the relationships, reflected in gamma ( $\gamma$ ), depict linear associations between a dependent variable and its predictor(s) and the extent to which the predictors capture variability in the dependent variable is reflected in the  $R^2$  value. Statistically significant direct effects were found between multiple factors (Table 4). The sociodemographic variables in  $BB_1$  that were significantly related to prescribed fire experience was the state in which the respondent lives, with Texas respondents having more experience than Oklahoma respondents ( $p < 0.001$ ). Consistent with  $BB_3$  and  $BB_4$ , property ownership motivations are directly linked to both prescribed fire and wildfire experience, respectively. Specifically, ownership for livestock production was shown to be positively related with prescribed fire experience ( $p < 0.001$ ), whereas ownership for investment and non-consumptive/ recreational purposes were negatively related with such experience ( $p < 0.001$ ).



**Figure 6.** Covariance structure analysis of the factors influencing the prescribed fire decision-making process. Statistically significant pathways denoted with bold arrows.

**Table 3.** Final model parameters for the prescribed fire decision-making model.

Dependent	Predictor	Constituent variable	Beta	Standard Error	$\gamma$	T value	R <sup>2</sup>
Prescribed fire experience	Socio-demo-graphic (BB <sub>1</sub> )	State of residence	0.186	0.027	0.192	6.824***	0.074
		Livestock production	0.120	0.026	0.119	4.552***	
	Ownership motivations (BB <sub>3</sub> )	Investment	-0.074	0.027	-0.074	-2.792***	
		Recreational uses	-0.072	0.027	-0.072	-2.684***	
Wildfire experience	Ownership motivations (BB <sub>4</sub> )	Crop production	0.144	0.040	0.144	3.625***	0.056
		Livestock production	0.212	0.039	0.212	5.423***	
Fire decision-making processes	Socio-demo-graphic (BP <sub>1</sub> )	Gender	0.233	0.037	0.231	6.241***	0.097
	Ownership motivations (BP <sub>2</sub> )	Recreational uses	-0.211	0.052	-0.210	-4.073***	

\*\*\*  $p < 0.001$ ,  $\chi^2 = 239.227$ ,  $df = 70$ , RMSEA = .0826, CFI = 1.000, NNFI = 1.000

Ownership for crop and livestock were found to be positively associated ( $p < 0.001$ ) with wildfire experience (BB<sub>4</sub>), suggesting that respondents with these two predominant property ownership motivations may have experienced or perceived greater losses from wildfire than the respondents with other landownership motivations. Two factors that were directly linked to the prescribed fire decision-making processes were: gender where male respondents were more likely to make decisions about prescribed fire than women ( $p < 0.001$ ); and property ownership for non-consumptive/recreational purposes which was negatively associated with prescribed fire decision-making process ( $p < 0.001$ ). This suggests that respondents who own land primarily for non-consumptive or recreational purposes are less likely to apply prescribed fire than respondents with other landownership motivations. The relationships between prescribed fire experience, wildfire experience, and perceived fire outcomes (BB<sub>5</sub>, BB<sub>6</sub>, and BB<sub>7</sub>, respectively) were not statistically significant.

The path analysis revealed five statistically significant relationships within the hypothesized process model for the decision to use prescribed fire. Men were more inclined to employ heuristics in their decision making compared to women who were more analytical. For property ownership motivations, for those motivated by non-consumptive recreational uses, their prescribed fire decision-making process were also more analytical. State of residence and property ownership motivation variables (livestock production, investment, and non-consumptive/recreational purposes) were also found to have significant associations with prescribed fire experience. Texas residents reported more experience as did respondents who reported undertaking livestock production. Alternately, respondent indicating property ownership motivates related to investment and non-consumptive recreational uses reported less prescribed fire experience. Finally, property ownership for livestock and crop production were found to have a direct and positive effect on wildfire experience.

## **Outreach and Science Delivery Activities**

The original research proposal stated: "*Texas A&M AgriLife Extension Service will design, create, and display exhibits during workshops to educate landowners on the importance of fire in fuels mitigation and wildfire abatement. With further support from the Great Plains Fire Science Exchange (GPFSE), we will produce at least one webinar and one extension fact sheet discussing prescribed burning management practices. [We] will also co-host four workshops (two each in Texas and Oklahoma) on the use of prescribed fire to contain woody plant expansion and to reduce fuel loads.*" Due to Covid-19 related travel restrictions it was impossible to host the in-person workshops. However, many other outreach and scientific products were created as summarized below (detailed information is included in Appendix B):

***Interactions with the Fire Science Exchange Network*** included four primary activities:

1. Webinar focusing on use of prescribed fire to restore rangelands burning in the Southern Great Plains presented by Urs Kreuter in 2016.
2. Online workshop focusing on use of the prescribed fire toolbox to combat identified social barriers, which included four presenters and 248 participants from four countries.
3. Four news briefs each focusing on one of the four presentations from the on-line workshop.
4. Outreach and Education Video produced by Heartland Productions, "Fighting fire with fire: Identifying social and legal barriers to prescribed burning in the Southern Great Plains"
5. Outreach and Education product "Prescribed burning communication kit". Co-developed by Texas A&M Agrilife Extension and the Great Plains Fire Science Exchange. RMFU-PU-352.

***Products and outputs that the project generated*** consisted of three areas of activity:

1. Outreach activities and products including: (a) A webinar by the project PI as part of the TAMU Rangeland, Wildlife, and Fisheries Management Stewardship Webinar series; (b) Three extension publications (ERM-022 7/16; ERM 035; and ERM 049); and (c) seven burn schools attended by a total of 465 participants.
2. Peer-reviewed journal manuscripts included: Seven manuscripts (three open access) published in five different journals including Environmental Management, Land, PLoS ONE, Rangeland Ecology and Management, and Society & Natural Resources.
3. Presentations at professional meetings included: invited keynote address at an international conference in South Africa; invitation to serve as an expert panelist during a discussion regarding prescribed fire liability at the *National Cohesive Wildland Fire Management Strategy Conference*, invitation by The Property and Environment Research Center and Tall Timbers Research Center to take part in a forum to discuss policy obstacles to the use of prescribed fire to manage western forests, invitation to present information related to prescribed burning statutes and liability to the Northeast & Midwest Prescribed Fire Council Regional Coordinating Committee, three invited oral presentations at international conferences, and three volunteered oral presentations at local, regional and national meetings.

***Future planned actions*** consist of two items:

1. Completion of the data analysis for the NRCS personnel interview and publication of a peer-reviewed manuscript focusing on the perspectives of NRCS personnel regarding barriers to the broader use of prescribed fire;
2. Seek funding opportunities for research focusing on the perspectives of District Court Judges and County Commissioners about the use of prescribed fire across the entire Great Plains.

## **Conclusions and Implications for Management/Policy and Future Research**

### **Heuristics in decision making**

The incorporation of heuristics into outreach and education programs has the potential to shift the perception and use of prescribed fire in a variety of contexts. To better engage individual landowners, county-level officials, and insurance underwriters, prescribed fire outreach and education programs should incorporate two additional components: (1) *Understanding individual fire experience* – For an individual using heuristics with negative cues about prescribed fire, identifying past experiences with fire might reveal the incident(s) responsible for the affective tag; once identified, new experiences can be created to supplant the negative effects of those incidents and to create a more positive attitude to the use of prescribed fire and, ultimately, more widespread use of this beneficial rangeland management tool. (2) *Addressing multiple process usage* – This would address two issues, the first being that many people seem to be unaware of their use of heuristics and, secondly, some demographic characteristics may be correlated with negative responses to the idea that decisions may be partially emotionally based.

More research on the diversity of heuristic effects on decision-making processes is necessary. ***Both qualitative and quantitative assessment of fire-related heuristics are necessary to better understand barriers to and opportunities for the use of prescribed fire in the SGP and more broadly in other fire-driven ecosystems.***

### **District Court Judges Mail Survey**

The findings of District Court Judges survey provide useful preliminary information to better understand how such Judges might adjudicate a case for damages from an escaped prescribed fire. Our data suggest that prescribed burn culture plays an important role in how laws are interpreted and applied by Judges. Some states have overcome variability in the interpretation of burner negligence by creating Right-to-Burn laws that provide more easily interpretable statutes with clear regulatory requirements tied to specific levels of liability. Our findings show that a Right-to-Burn act that prescribed lower liability for Certified Prescribed Burn Managers would likely reduce the types of evidence that Judges in Texas and Oklahoma perceive as constituting evidence of negligence, thereby limiting burner liability in these states.

However, due to the low sample size and low response rate we were unable to conduct rigorous statistical analyses. One factor that negatively influenced response rate was the unwillingness of Judges to provide their opinions on hypothetical legal matters pertaining to prescribed fire. Based on this we recommend that future research should incorporate a much larger survey sample of Judges and should adopt a mixed-methods approach that combines a mail survey with personal or telephone interviews. This approach will help build rapport with Judges, reduce their concerns over confidentiality and increase their willingness to provide input for such research (Dobbin et al. 2001). ***We recommend a survey of Judges across the Great Plains that uses a mixed methods approach to more broadly understand Judges' perceptions and application of prescribed fire laws and regulations across the central USA where periodic fire is necessary.***

## County Commissions Mail Survey

In our study of County Commissioners, most of the respondents reported being comfortable with prescribed fire due to their familiarity with this land management tool. Nevertheless, in their capacity as public officials, many Commissioners appeared to align more with fire prevention attitudes and seemed inclined to pre-emptively enact burn bans and reluctant to approve exemptions to such bans when conditions are conducive for high-intense fires that most effectively suppress invasive woody plants and reduce accumulated fuel loads. Many commissioners reported that they depended on input from emergency personnel when making decisions about enacting a burn ban. These findings imply that invitations from trusted landowners and PBA members to Commissioners and key emergency personnel to participate in prescribed fires applied during a burn ban could moderate attitudes about escaped fire risk, leading to fewer long-term burn bans and more burn ban exemptions. Our finding that a change in legal liability statutes for escaped fire from simply to gross negligence might not affect Commissioners' decisions regarding the enactment of burn bans, suggests that such a shift in legislation might not increase the windows of opportunity for applying prescribed fire, especially in Texas. However, this finding is inconsistent with a survey of District Court Judges regarding prescribed fire liability (Hinojosa et al. 2020). Moreover, the stronger pro-fire culture in Oklahoma, which like Texas has a simple negligence statute for escaped fire, suggests that a shift in liability statute may not be a precondition for increasing prescribed fire use, but rather that certain changes in the language of current statutes could decrease uncertainty about outcomes of law suits pertaining to escaped fire and, therefore, increase prescribed fire use.

While our study provides useful initial findings about Commissioners' familiarity and level of comfort with fire, criteria they would use to enact burn bans, and their perspectives about the potential effect in escaped fire liability standards on burn ban enactment, our study left many important questions unanswered. *A future study across the entire Great Plains is recommended to determine if our findings about burn ban decision-making have broader applicability.*

## Landowner Mail Survey

In predominantly private land areas, landscape-scale prescribed fire can only be achieved by enhancing prescribed fire use by individual landowners. Our investigation conceptualized a process-focused decision-making model that views multiple barriers to prescribed fire use as process inputs with barrier-barrier (BB) and barrier-process (BP) relationships. Path analysis determined multiple significant BB relationships, including between prescribed fire experience and state of residence, as well as between wildfire experience and land ownership for livestock or crop production. Significant BP relationships included those between the fire decision-making process and gender, and property ownership for non-consumptive/recreational use. These findings provide a first approximation of a process model of human decisions regarding prescribed fire use; they have implications for three landscape-scale prescribed fire issues: 1) the provision of an evolved conceptualization through which prescribed fire implementation decisions can be examined, 2) enhancing prescribed fire outreach to a changing landowner population, and 3) improving the content and delivery of prescribed fire education efforts.

However, our study had some limitations. Compared to the survey respondents, non-respondents had owned their property for a longer period of time, had a generally more negative opinion of prescribed fire as a rangeland management tool, and perceived prescribed fire to be less effective

both in terms of wildfire fuel load reduction and woody plant control. Future investigations into decision-making concerning prescribed fire would benefit from inclusion of a larger portion of more recent landowners who represent the increasing trend in ethnic and ownership motivation diversity of landowners. Further, the model could also be improved by including factors such as the impact of past PBA membership effects on prescribed fire opinions and individual interpretations of escaped prescribed fire court judgements and relevant legal proceedings. Another improvement might include a way to gauge the ‘permeability’ of certain barriers; e.g, burn bans represent relatively impermeable barriers while an individual’s experience with wildfire could change dramatically in a short period changing the impact of their wildfire experience on prescribed fire decisions (Hoffman et al. 2021). ***In order to enhance the decision-making process model, we recommend future research that expands the diversity of the survey sample, and includes as explanatory variables PBA membership, landowners’ perceptions of court judgements, and obstacles that are prone to permeability shifts and how those shifts impact fire implementation decisions.***

## Literature Cited

- Armstrong, J.S., Overton, T.S. 1977. Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, 14: 396-402.
- Assal, T. J., Melcher, C. P., Carr, N. B. 2015. Southern Great Plains Rapid Ecoregional Assessment: Pre-assessment Report (No. 2015-1003). US Geological Survey.
- Bendel, C., Toledo, D., Hovick, T., McGranahan, D. 2020. Using behavioral change models to understand private landowner perceptions of prescribed fire in North Dakota. *Rangeland Ecology & Management*, 73(1): 194-200.
- Brenner, J., Wade, D. 2003. Florida's revised prescribed fire law: Protection for responsible burners. Pages 132-136 in K.E. Galley, R.C. Klinger, and N.G. Sugihara (eds.). Proceedings of Fire Conference 2000: The first national congress on fire ecology, prevention, and management. Miscellaneous Publication No. 13, Tall Timbers Research Station, Tallahassee, FL.
- Briggs J.M., Knapp, A.K., Blair, J.M., Heisler, J.L., Hoch, G.A., Lett, M.S., McCarron, J.K. 2005. An ecosystem in transition: Causes and consequences of the conversion of mesic grassland to shrubland. *BioScience*, 55: 243-254.
- Dillman, D.A., Smyth, J.D., Christian, L.M. 2014. Internet, phone, mail, and mixed-mode surveys: The tailored design method. New York, NY: John Wiley.
- Dobbin, S.A., Gatowski, S.I., Ginsburg, G.P., Merlino, M.L., Dahir, V., Richardson, J.T. 2001. Surveying difficult populations: Lessons learned from a national survey of State Trial Court Judges. *The Justice System Journal*, 22(3): 287-314.
- Donovan, V. M., Wonkka, C. L., Wedin, D. A., Twidwell, D. 2020. Land-Use Type as a Driver of Large Wildfire Occurrence in the US Great Plains. *Remote Sensing*, 12(11): 1869.
- Eburn, M., Cary, G.J. 2018. You own the fuel, but who owns the fire? *International Journal of Wildland Fire*, 26(12): 999-1008.
- Elmore, R.D., Bidwell, T.G., Weir, J.R. 2010. Perceptions of Oklahoma residents to prescribed fire. Pages 50–61 in K.M. Robertson, K.E.M. Galley, R.E. Masters (eds.). Proceedings of the 24th Tall Timbers Fire Ecology Conference: The Future of Prescribed Fire: Public Awareness, Health, and Safety. Tall Timbers Research Station, Tallahassee, Florida, USA.
- Fischer A.P., Charnley, S. 2012. Risk and cooperation: Managing hazardous fuel in mixed ownership landscapes. *Environmental Management*, 49(6):1192–1207.
- Fuhlendorf, S.D., Archer, S.R., Smeins, F.E., Engle, D.M., Taylor Jr, C.A. 2008. The combined influence of grazing, fire, and herbaceous productivity on tree–grass interactions. In: Van Auken, O.W. (Ed), Western North American *Juniperus* communities: a dynamic vegetation type. Springer-Verlag, New York, NY, USA.
- Haines, T.K., Busby, R.L., Cleaves, D.A. 2001. Prescribed burning in the south: Trends, purpose, and barriers. *Southern Journal of Applied Forestry*, 25(4): 149-153.

- Haines, T.K., Cleaves, D.A. 1999. The legal environment for forestry prescribed burning in the south: Regulatory programs and voluntary guidelines. *Southern Journal of Applied Forestry*, 23(3): 170.
- Hinojosa, A., Wonkka, C.L., Kreuter, U.P. 2020. Liability and the use of prescribed fire in the Southern Plains, USA: A survey of District Court Judges. *Land*. 9-318  
<http://dx.doi.org/10.3390/land9090318>
- Hoffman, J.K., Bixler, R.P., Treadwell, M., Coleman, L., McDaniel, T.W., Kreuter, U.P. 2021. The impact of heuristics in decision-making regarding the implementation of prescribed fire on private rangelands in the Southern Great Plains, USA. *Society & Natural Resources*. 34(5): 621-638.
- Kreuter, U.P., Woodard, J.B., Taylor, Jr., C.A., Teague, W.R. 2008. Perceptions of Texas landowners regarding fire and its use. *Rangeland Ecology and Management*, 61: 456-464.
- Luo, L., Tang, Y., Zhong, S., Bian, X., Heilman, W.E. 2013. Will future climate favor more erratic wildfires in the Western United States? *Journal of Applied Meteorology and Climatology*, 52: 2410-2417
- Miller, R.K., Field, C.B. Mach, K.J. 2020. Barriers and enablers for prescribed burns for wildfire management in California. *Nature Sustainability*, 3(2): 101-109.
- North, M.P., Stephens, S.L., Collins, B.M., Agee, J.K., Aplet, G., Franklin, J.F., Fulé, P.Z. 2015. Reform forest fire management: Agency incentives undermine policy effectiveness. *Science*, 349: 1280-1281
- Samson, F., Knopf, F. 1994. Prairie conservation in North America. *BioScience*, 44: 418-421
- Samson, F.B., Knopf, F.L., Ostlie, W.R. 2004. Great Plains ecosystems: Past, present, and future. *Wildlife Society. Bulletin*, 32: 6-15
- Sorice, M.G., Kreuter, U.P., Wilcox, B.P., Fox III, W.E. 2014. Changing landowners, changing ecosystem? Land-ownership motivations as drivers of land management practices. *Journal of Environmental Management*, 133: 144-152
- Taylor, C.A., 2005. Prescribed burning cooperatives: empowering and equipping ranchers to manage rangelands. *Rangelands*, 27:18-23.
- Toledo, D., Kreuter, U.P., Sorice, M.G., Taylor Jr. C.A. 2012. To burn or not to burn: Ecological restoration, liability concerns and the role of prescribed burning associations. *Rangelands*, 34: 18-23
- Toledo, D., Sorice, M.G., Kreuter, U.P. 2013. Social and ecological factors influencing attitudes toward the application of high-intensity prescribed burns to restore fire adapted grassland ecosystems. *Ecology and Society*, 18(4): 9 <http://www.ecologyandsociety.org/vol18/iss4/art9/>
- Toledo, D., Kreuter, U.P., Sorice, M.G., Taylor Jr., C.A. 2014. The role of prescribed burn associations in the application of prescribed fires in rangeland ecosystems. *Journal of Environmental Management*, 132: 323-328

- Tversky, A., Kahneman, D. 1974. Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157): 1124-1131. 10.1126/science.185.4157.1124.
- Tversky, A., Kahneman, D. 1981. The framing of decisions and the psychology of choice. *Science*, 211(4481): 453-458. <https://doi.org/10.1126/science.7455683>.
- Twidwell, D., Rogers, W.E., Fuhlendorf, S.D., Wonkka, C.L., Engle, D.M., Weir, J.R., Kreuter, U.P., Taylor Jr. C.A. 2013. The rising Great Plains fire campaign: Citizenry response to woody plant encroachment. *Frontiers in Ecology and the Environment*, 11 (Online Issue 1): e64–e71, doi:10.1890/130015
- Twidwell, D., Wonkka, C.L., Sindelar, M.T., Weir, J.R. 2015. First approximations of prescribed fire risks relative to other management techniques used on private lands. *PLoS ONE*, 10(10):e0140410. doi:10.1371/journal.pone.0140410
- Twidwell, D., Rogers, W.E., Wonkka, C.L., Taylor Jr, C.A., Kreuter, U.P. 2016. Extreme prescribed fire during drought reduces survival and density of woody resprouters. *Journal of Applied Ecology*, 53(5): 1585-1596.
- Weir, J.R., Kreuter, U.P., Wonkka, C.L., Twidwell, D., Stroman, D.A., Russell, M., Taylor, C.A. 2019. Liability and prescribed fire: perception and reality. *Rangeland Ecology and Management*, 72: 533-538.
- Wonkka, C.L., Rogers, W.E., Kreuter, U.P. 2015. Legal barriers to effective ecosystem management: exploring linkages between liability, regulations, and prescribed fire. *Ecological Applications*, 25: 2382-2393
- Yoder, J., Engle, D., Fuhlendorf, S. 2004. Liability, incentives, and prescribed fire for ecosystem management. *Frontiers in Ecology and the Environment*, 2: 361-366.

**Appendix A:**  
**Contact Information for Key Project Personnel**

**Urs P. Kreuter, Professor**

Texas A&M University, Department of Ecology and Conservation Biology  
Building #1537 - 534 John Kimbrough Blvd,  
College Station, Texas 77843-2258  
E-mail: [urs@tamu.edu](mailto:urs@tamu.edu)  
Phone: 979-255-2022

**Morgan L. Treadwell (Russell), Associate Professor**

Texas A&M AgriLife Extension, Department of Range, Wildlife and Fisheries Management  
7887 U S Highway 87 North San Angelo, TX 76901  
E-mail: [Morgan.Treawell@ag.tamu.edu](mailto:Morgan.Treawell@ag.tamu.edu)  
Phone: (325) 657-7317

**R. Patrick Bixler, Assistant Professor**

The University of Texas, LBJ School of Public Affairs, Community and Regional Planning,  
RGK Center for Philanthropy and Community Service  
P.O. Box Y, Austin, TX 78713-8925  
E-mail: [rpbixler@utexas.edu](mailto:rpbixler@utexas.edu)  
Phone: (512) 471-3988

**Carissa L. Wonkka, Research Ecologist**

USDA Agricultural Research Service, Northern Plains Agricultural Laboratory,  
1500 N Central Ave, Sidney, Montana 59270  
E-mail: [carissa.wonkka@usda.gov](mailto:carissa.wonkka@usda.gov)  
Phone: (406) 433-9416

## **Appendix B:**

### **Completed/Planned Scientific/Technical Publications/Science Delivery Products**

#### ***Interactions with the Fire Science Exchange Network***

1. Morgan Treadwell with Taylor Fey. 2021. Outreach and Education Video: "Fighting fire with fire: Identifying social and legal barriers to prescribed burning in the Southern Great Plains". Heartland Productions, Ventress, Louisiana
2. Treadwell, M.L. 2020. [Organizer, Host, Moderator] Fighting fire with fire: Rx fire toolbox to combat identified social barrier. Great Plains Fire Science Exchange On-line Workshop, 09:00-12:30 CST, 27 July. 471 registrants, 248 participants, 4 different countries.  
Recording: <https://gpfirescience.org/resources/fighting-fire-with-fire-workshop-recording/>
  - a) Kreuter U.P. Introduction - Fighting wildfire with prescribed burning in the Southern Great Plains
  - b) McDaniel, T.W., Wonkka, C.L., Treadwell, M.L., Kreuter, U.P. Factors Influencing County Commissioners' Decisions about Burn Bans in the Southern Plains, USA
  - c) Hinojosa, A. Kreuter, U.P., Wonkka, C.L. Liability and prescribed fire use: A survey of District Court Judges
  - d) Coleman, L., Landowner perception of information about prescribed fire: Influence on the application of this land management tool in the Southern Great Plains
3. Great Plains Fire Science Exchange Research Briefs
  - a) Thomas McDaniel, Carissa Wonkka, Morgan Treadwell, Urs Kreuter. 2020. Prescribed Fire in the Southern Great Plains: Factors influencing county commissioners' decisions about burn bans. GPE publication 2020-1
  - b) Alissa Hinojosa, Carissa Wonkka, Morgan Treadwell, Urs Kreuter. 2020. Prescribed Fire in the Southern Great Plains: District judges' perspectives of prescribed fire. GPE publication 2020-2
  - c) Lars Coleman, Carissa Wonkka, Morgan Treadwell, Urs Kreuter. 2020. Landowner perception information about prescribed burning: Influence on the application of this land management tool in the Southern Great Plains. GPE publication 2020-3
  - d) Urs Kreuter, Morgan Treadwell. 2020. Fighting wildfire with prescribed burning in the Southern Great Plains: Social and regulatory barriers and facilitators. GPE publication 2020-4
4. Outreach and Education product "Prescribed burning communication kit". 2020. Co-developed by Texas A&M Agrilife Extension and the Great Plains Fire Science Exchange. RMFU-PU-352.
5. Urs Kreuter. 2016. Restoring rangelands and fighting wildfire with prescribed burning in the Southern Great Plains. Great Plains Fire Science Exchange Webinar, 9 November.

## ***Products and outputs that the project generated***

### Outreach activities and products

1. Urs Kreuter, U.P. 2021. Fighting wildfire fire with Rx fire: Identifying and overcoming social barriers. TAMU Rangeland, Wildlife, and Fisheries Management Stewardship Webinar, May 6. Texas A&M AgriLife Extension, San Angelo, Texas. 34 participants.  
<https://www.youtube.com/watch?v=3WPLUu93crY>
2. Treadwell, M.L, Kreuter U.P. 2021. [Organizers and Hosts] Special Session: Fighting fire with fire – Rx fire toolbox to combat identified social barriers. 74<sup>th</sup> Annual Meeting, Society for Range Management, 15-17 February, Boise, Idaho - Virtual Meeting.
3. Knapik, K., M. Treadwell, R. Knight, U. Kreuter, R. Lopez. 2020. Prescribed fire: A tool for landowners large and small. Texas A&M AgriLife Extension Publication ERM-049.
4. Russell, M.L., Lashmet, T. 2017. Prescribed burning: Liability and insurance considerations. Texas A&M AgriLife Extension Publication ERM-035.
5. Russell, M.L, C.L. Wonkka, W.E. Rogers, U.P. Kreuter. 2016. Legal barriers to prescribed burning. Texas A&M AgriLife Extension Publication ERM-022 7/16.
6. Burn Schools:
  - a) Prescribed Burn School. 120 participants. July 13, 2017 San Angelo, TX.
  - b) Prescribed Burn School. 109 participants. September 13, 2018 San Angelo, TX.
  - c) Prescribed Burn School. 34 participants. May 29-31, 2019 Fredericksburg, TX.
  - d) Growing Season Burn Workshop. 48 participants. August 29, 2019 Gainesville, TX.
  - e) AgriLife Learn Online Prescribed Burn School. 120 participants.  
<https://agrillifelearn.tamu.edu/s/product/prescribed-burn-school/01t4x000002ciQyAAI>
  - f) Prescribed Burn School. 28 participants. June 11, 2021. Mertzon, TX.
  - g) Prescribed Burn School. 6 participants. September 17, 2021. Eldorado, TX.

### Graduate Student Theses and Dissertations

Thomas W. McDaniel. August 2018. Prescribed Fire Outreach in the Southern Great Plains: Challenges and Opportunities Master of Science Thesis. Department of Ecosystem Science and Management, Texas A&M University

Alissa M. Hinojosa. May 2019. Prescribed Fire in the Southern Great Plains: Legal and Regulatory Roles. Master of Science Thesis. Department of Ecosystem Science and Management, Texas A&M University

Lars Coleman. August 2019. Landowner Perception of Information about Prescribed Fire: Influence on the Application of this Land Management Tool in the Southern Great Plains. Master of Science Thesis. Department of Ecosystem Science and Management, Texas A&M University

James Kelly Hoffman. August 2020. Implementing Fire with Feeling: The Role of Heuristics and Process Modelling in Navigating Social Barriers to Landscape-Scale Prescribed Fire Use in the Southern Great Plains, USA. Doctor of Philosophy Dissertation. Department of Ecosystem Science and Management, Texas A&M University

#### Peer-reviewed journal manuscripts

1. Hoffman, J.K., Kyle, G.T., Treadwell, M.L., Bixler, R.P., Kreuter, U.P. 2021. A process-oriented model of decision-making toward landscape-scale prescribed fire implementation in the Southern Great Plains, USA, *Environmental Management*, *In Press*  
<https://link.springer.com/article/10.1007%2Fs00267-021-01538-y>
2. McDaniel, T.W., Wonkka, C.L., Treadwell, M.L., Kreuter, U.P. 2021. Influencing County Commissioners' decisions about burn bans in the Southern Plains, USA. *Land*, 10, 686.  
<https://doi.org/10.3390/land10070686>
3. Hoffman, J.K., Bixler, R.P., Treadwell, M., Coleman, L., McDaniel, T.W., Kreuter, U.P. 2021. The impact of heuristics in decision-making regarding the implementation of prescribed fire on private rangelands in the Southern Great Plains, USA. *Society & Natural Resources*. 34(5): 621-638.
4. Hinojosa, A., Wonkka, C.L., Kreuter, U.P. 2020. Liability and the use of prescribed fire in the Southern Plains, USA: A survey of District Court Judges. *Land*. 9-318  
<http://dx.doi.org/10.3390/land9090318>
5. Stroman D.A., Kreuter, U.P. 2020. Landowner perceptions and preferences of woody plant expansion in the Southern Great Plains: Implications for management. *PLoS ONE* 15(9): e0238688. <https://doi.org/10.1371/journal.pone.0238688>
6. Kreuter, U.P., Stroman, D.A., Wonkka, C., Weir, J., Abney, A.A., Hoffman, J.K. 2019. Landowner perceptions of legal liability for using prescribed fire in the Southern Plains, USA. *Rangeland Ecology and Management*, 72: 959-967
7. Weir, J., Kreuter, U.P., Wonkka, C.L., Stroman, D.A., Russell, M., Twidwell, D., Taylor, C.A. 2019. Liability and Prescribed fire: Perception and reality. *Rangeland Ecology & Management*, 72: 533-538

#### Presentations at professional meetings

1. Wonkka, C.L. Expert panellist: Gross Negligence and Prescribed Fire Liability in the US. 4<sup>th</sup> National Cohesive Wildland Fire Management Strategy Workshop. October 4, 2021. [Virtual meeting]
2. Kreuter, U.P., C.L. Wonkka. 2021. [Volunteered] Fighting wildfire fire with prescribed fire: Identifying and overcoming social barriers. 56<sup>th</sup> Congress of the Grassland Society of Southern Africa. 26-30 July, Oudtshoorn, South Africa [Virtual meeting]
3. Kreuter, U.P. 2021. [Invited] Prescribed Burning Associations: A proactive mechanism for expanding Rx use to combat wildfire. In: Special Session: Fighting fire with fire – Rx fire toolbox to combat identified social barriers. 74<sup>th</sup> Annual Meeting, Society for Range Management, 15-17 February, Boise, Idaho [Virtual Meeting].
4. Hoffman, J.K. L. Coleman, W. McDaniel, P. Bixler, M. Russell, U. Kreuter. 2019. [Invited] Heuristics and fire: Decision-making processes and prescribed fire implementation in the Southern Great Plains. 8<sup>th</sup> International Fire Ecology and Management Congress: Cultivating Pyro-diversity, 18-19 November, Tucson, Arizona Arizona.

5. Hoffman, J.K., L. Coleman, T.W. McDaniel, R.P. Bixler, M. Russell, U.P. Kreuter. 2018. [Volunteered] Social obstacles to prescribed fire in the Southern Great Plains. Presented at the 2<sup>nd</sup> Great Plains Fire. October, Summit, Ardmore, Oklahoma.
6. Hoffman, J.K., L. Coleman, T.W. McDaniel, R.P. Bixler, M. Russell, U.P. Kreuter. 2018. [Volunteered]. Affective reasoning and heuristics: potential impact on perceived risk of prescribed fire implementation in the Southern Great Plains. Ecological Integration Symposium, April, Texas A&M University, College Station, Texas.
7. Kreuter U.P. 2018. [Invited] Comprehensive assessment of ecosystem service dynamics in Savannas: ISSEC – A social-ecological system framework. 16<sup>th</sup> Savanna Science Network Meeting, 4-8 March, Skukza, S. Africa
8. Hoffman, J.K., L. Coleman, T.W. McDaniel, R.P. Bixler, M. Russell, U.P. Kreuter. 2018. [Volunteered]. Acceptable and perceived risk: Prescribed fire in the Southern Great Plains. Presented at the 71<sup>st</sup> Annual Society for Range Management Meeting, 28 January-2 February, Reno, Nevada.
9. Kreuter, U.P. 2017. [Invited Keynote Address]: Social and legal barriers and opportunities for using prescribed fire on private land in the Southern Great Plains, USA. 52<sup>nd</sup> Congress of the Grassland Society of Southern Africa, 23-27 July, 2017, Hoedspruit, South Africa.

## **Appendix C: Metadata**

The research of the type incorporated in this project were exempt from NEPA compliance under categorical exclusion No. 1.4 B (1), 516 DM Appendix 1 and did not require procedural clearances. However, the research was subject to compliance with Human Subjects Research. Application for this compliance was obtained through the Institutional Review Board at Texas A&M University with the following IRB ID numbers: IRB2017-0364M; IRB2017-0735M; and IRB2018-0015.

All interviews and mail surveys in this project were conducted with assurances of confidentiality for the participants. As such, the raw research data cannot be released to a public. However, the raw data are being kept in secure storage for a period of at least 5 years after completion of the project. Moreover, the aggregated research results are provided to the public in numerous peer-reviewed journal manuscripts and outreach products all listed in Appendix B.